Title of the Paper

SOCIOECONOMIC AND INSTITUTIONAL DETERMINERS OF DURABLE TECHNOLOGICAL INNOVATIONS IN THE FOOD-PRODUCING AGRICULTURE OF CAMEROON

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Topics: Restructuring supply chains – exclusion of smallholders, technological choices

Abstract

The challenges posed by food security for populations in sub-Saharan Africa and the fact that extensive production systems are reaching their limits in food-producing agriculture imply accelerating technological innovation toward ecological intensification of agricultural production systems. A review of research on plantain banana in Cameroon since 1988 revealed how institutional innovation enabled hybridization of different forms of research (fundamental, systems, and action research) and reinforced the organizational innovation required for technical change. Evaluation of impacts underlined the complementarity between an increase in productivity and in income in rural areas, the production of human and social capital and the protection of forest resources.

Key words: Innovation – food crops – Cameroon – sustainable development - plantain

Introduction

Population growth in sub-Saharan Africa is characterized by a rapid increase in urban populations that is without precedent in the history of the world. Available statistics[1] emphasize a decrease in productivity in food-producing agriculture (plantain, *malaga*, cassava, etc.). These observations draw attention to the need to transform food-producing agriculture to help ensure the food security of the populations, and to increase income in rural areas. The lack of an increase in productivity in food-producing agriculture in this region can be explained by several different variables. Political crises disrupt the institutional conditions required for expansion of agricultural productivity. State disengagement from the organization of the support services required by agriculture (credit, agricultural extension, infrastructure, etc.); competition from cheap -sometimes subsidized- food imports (wheat, rice, chicken, etc.) and the lack of protection of food-producing agriculture in the face of world markets. And finally, insufficient investment in research on food crops and the fact that any such investment is not efficient in terms of impact.

According to available data, in the next 20 years food security in sub-Saharan Africa will continue to be uncertain. Among food crops, plantain banana, with an annual production of three million tonnes in central Africa [2] plays a major role in the food supply of the population. Formerly mainly produced for home consumption (Bikoï, 2000), today more than 50% is sold. The transition from an agricultural system based on home consumption to sales has resulted in diversification of the socio-economic conditions of production, as well as in technical pathways. It has also modified social demand for research in different disciplines. She questions us about the understanding of socioeconomic and institutional determiners of sustainable technical innovation in the food-producing agricultures of developing countries?

We suggest to answer this question through the test of 3 hypothesis:
- the knowledge of socioeconomic stakes, which structure the conditions of emergence of the sectors, is necessary for the efficiency of the technical research,
- hybridization between various research forms (fundamental, system, action, participative) is a key determiner of the technical innovation,
- technical innovation produces impacts on the sustainable development, and more particularly in reducing poverty

To test these hypothesis, we make use of an analytical frame in which three knowledge sets intersect: i) contributions of savings resulting from innovations and institutional contributions, ii) the conceptual tools provided by participatory and action research, iii) the contributions from agricultural technical disciplines (agronomy, entomology, etc.). From an empirical point of view, we use this frame to summarize the studies and data bases containing information on plantain banana production in Cameroon created from 1988.

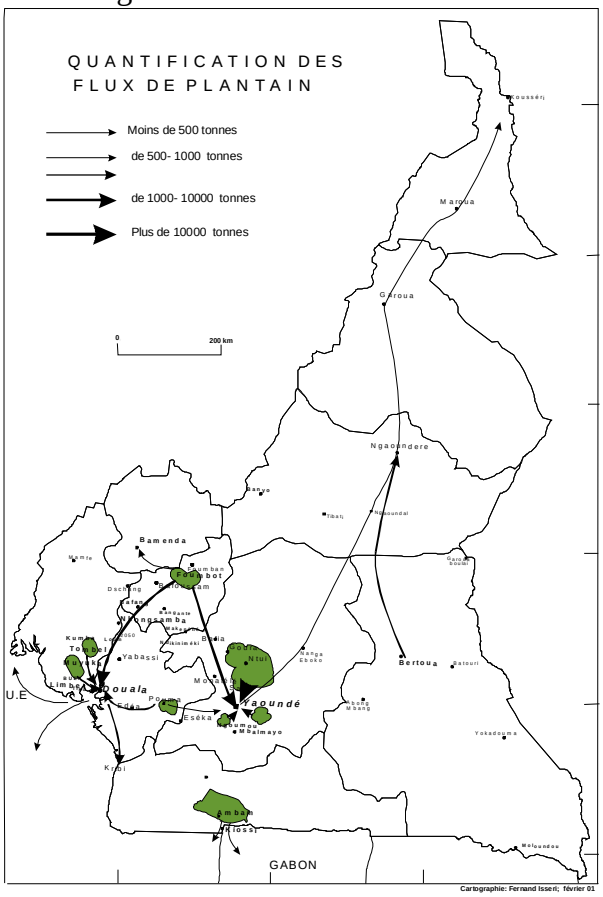
1 FAO-STAT : http//apps.fao.org/faostat/
2 Cemac countries + RDC.

I. How analyzing a sector increases the efficiency of technical research

Available analyses on the determinants of technical change call attention to three dimensions: i) the capacity to « hybridize » empirical innovation processes produced by farmers and those produced by scientific research (Chevassus, 2006); ii) the capacity to take into account the systemic functioning of agriculture (Lauret, 1992); and finally iii) the need to consider long term perspectives (technological pathways). In the first section of this paper we demonstrate how characterization of mesosytems by analyzing the plantain [3] sector in Cameroon (Chataigner, 1988) can play a major role in technical change in food-producing agriculture.

Analysis of the sector to characterize limiting factors

Along with cassava and cocoyam, plantain banana is one of the basic components of agriculture and of the diet of the population of sub-Saharan Africa. In Cameroon, annual consumption is 40 kg per person per year in towns [4] where the population is constantly increasing. Plantain is one of the favorite consumer products but is nevertheless becoming a luxury good. Consumer prices are already high and still rising (Dury, 2002). These high prices reflect the difficulties in adapting supply systems (production, marketing conditions) to urban demand. Studies were consequently conducted to characterize the supply chains (identification of actors, markets, identification of and quantification of flows, identification of the main production areas (Temple et al. 1996). Four main production areas were identified:

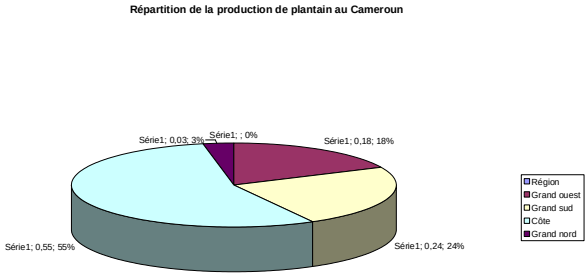


- ð the first area supplies Douala (approx. 2 million inhabitants) and the South-west and Coastal provinces, (55% of total production in Cameroon)
- ð the second area supplies Yaoundé (approx. 1.5 million inhabitants) and the north of Cameroon (24% of total production),
- ð the third area supplies the « *grand ouest* », but also supplies Yaoundé and Douala [5] in the off season (18% of total production),
- ð the fourth recently developed area near the southern frontier supplies

3 The plantain banana is a semi-perennial herbaceous plant: its growth cycle is longer than 12 months; with vegetative multiplication a plantation can continue producing for four years under industrial production conditions, and for around thirty years in agro-forest gardens.

4 Women who purchase plantain bananas can distinguish between from jour to around 10 cultivars, the quality depends on the origin of the product which determines flavor, cooking time and consistency.

5 In the « *grand ouest* », consumers prefer cooking bananas to plantain, while in the south, consumers prefer plantains.



The location of production areas helped decide on priority areas for research or for the identification of limiting factors at the level of the supply chains or of the production systems.

Research revealed a specialization process in certain areas characterized by a local increase in the proportion of producers for whom plantains play a major role in the functioning of the farm[6]. Specialization leads to closer geographical proximity and speeds up the process by which farmers follow other farmers' examples. Specialization also results in spatial concentration of production, which, in turn, facilitates the creation of wholesale markets meaning the cost of transport for collection of the produce is cheaper than when production is dispersed. On the other hand, the development of monoculture facilitates the rapid spread of diseases and extensive adaptation of technical itineraries is required to overcome new phytosanitary constraints. An executive summary of diagnostic surveys of supply chains and production systems since 1988 that was validated at a consultative workshop for operators in the sector (Temple et al. 2000), revealed three interrelated groups of constraints:

- the existence of a bottleneck [7] in the supply of healthy planting material (suckers);
- lack of change in technical itineraries in the face of the increase in phyto-technical constraints in areas where reserves of fertility are being depleted or where monoculture is on the increase;
- malfunctioning markets (Nkendah et al. 2007) which fail to pass on to producers increases in the price paid by the consumer.

Bottleneck created by the lack of planting material

Analyses of supply chains revealed a serious limiting factor related to the quantitative and qualitative lack of supplies of planting material (suckers). This has two main consequences: first, planters collect suckers from old plots under fallow (approx. 80% of suckers) thereby transferring significant quantities of contaminated planting material to healthy plots; second, in the absence of chemical treatment, production cycles last only four years, produce low yields, and a resulting shift in the production area. These consequences were observed during permanent monitoring of farms (Pierrot et al., 2002), confirming on the one hand, serious constraints linked to soil parasites [8] (losses of more than 50% in production after the third cycle), and, on the other hand, the secondary importance of black cercosporiosis in the

6 Questions concerning the pertinence of the farming concept to account for the different organizational forms of African agriculture are not discussed in this article.
7 A bottleneck refers to a place in the supply chain where a product is in short supply.
8 Nematodes and pests (Curculionidae)

production conditions faced by family farmers in Central Africa. This disease has been identified as a priority for genetic research.

Lack of change in technical itineraries and increase in phytosanitary pressure

In spite of the intensity of urban demand and increased pressure on land resources, available data on yield show that production systems continue to be extensive [9]. One explanation is satisfactory labor productivity under this system which is based on natural renewal of soil fertility, but involves an increase in the use of new land (forest reserves), spatial dispersion, and high marketing costs. In practice, these extensive systems have started to adapt in several different ways:

- Firstly by *changes in crop associations* that include plantain, food crops (*macabo*, groundnuts, maize etc.) or perennial crops (cocoa, coffee, oil palm), changes in planting density, in crop combinations (rotation, associations) and in cultivation techniques (fallow, ridging, staking, etc.). One economic determinant of these changes is the search for economies of scale (the complementarity of different crops) to ensure food needs are met (phasing of harvest with respect to a food calendar), to make optimal spatial use of land (juxtaposition of several strata of crops in an association), and of time (the labor needed for clearing and weeding serves several crops). These strategies maintain labor productivity as soil fertility declines (Achard et al, 1996).

- By the *emergence of banana monoculture* in three situations: in the vicinity of towns, thanks to investment in agriculture of capital from other sectors by people who have several activities; in the framework of diversification efforts by agro-industrial banana companies; and finally, family farmers who implement technical schemes diffused by researchers. However, the development of monoculture is resulting in an increase in pressure from black cercosporiosis.
Control of this disease requires either spraying from the air, which is too expensive for family farms and causes environmental pollution that is damaging for human health, or the use of resistant hybrids. Such hybrids are currently rarely used by farmers outside experimental networks.

In the family food-producing agriculture we are concerned with here (cultivation of tropical amylacea), except in the vicinity of towns where the focus is on market gardening (Gockowski et al. 2004) technical changes do not envisage the intensive use of inputs (pesticides, fertilizers) that characterizes agriculture in industrialized countries. One explanation is the desire to avoid creating financial risk for small farms in a context of unstable plantain prices and a lack of stable finance structures for farmers: the implicit cost of financial resources for family agriculture is high[10].

These technical changes do not suffice to meet the demand of urban markets, as evidenced by rising consumer prices and the spatial mobility of production. The Department of Léiké,

9 Low yields from plots under monoculture may be due to space occupied by felled trees (valorization of forest resources) or the lack of suckers.
10 The use of a cash income in a situation of financial uncertainty is subject to the alternative of ensuring human health, education or the acquisition of plant protection products, etc.

which was formerly able to supply Yaoundé, can no longer feed its own population, and people living in areas with serious population pressure are migrating to pioneer fronts: the towns. In Cameroon, food imports per person are increasing faster than the rate of increase in the population. Given the existing institutional context, the specificities of family food production, and the environmental dangers of the intensive use of chemical inputs (pesticides, fertilizers [11]) favored by conventional agricultural research in developing countries (Nkamleu et al.2000), this trend calls on the capacity for technological adaptation of food-producing agriculture.

II. How hybridization of different forms of research (fundamental, systems, action, participatory research) speeds up technical innovation

Here we define technical innovation as a process that distinguishes an invention (a technique, a type of organization, a hybrid, etc.) that can be generated by a farmer, a researcher, or an organization within the sector, from innovation that represents the integration of the invention in a productive system. This integration may or may not be supported by agents who are not themselves farmers: managers, researchers, etc. (Sibelet, 2005). In fact, it implies the capacity to « hybridize » on the one hand, the different sources of the creation of the invention (fundamental research, empirical research), and on the other hand, the different processes that integrate the invention in a productive system. In this way, a technical innovation depends to a large extent on institutional and organizational innovation that structures the coordination between the actors required for its implementation. It implies that the job of the researcher is no longer limited to producing an invention or producing knowledge but that he or she is responsible (directly or indirectly) for ensuring that the three dimensions (technical, organizational and institutional) that give rise to the innovation are taken into account. This activation mobilizes the concepts of action research and the tools of participatory research.

Another determinant of the innovation process is the need to take the historical dimension (the long term) into account, as this ensures coherence between ways of organizing production, technological choices, incremental innovations, and collective values. The degree of coherence in the integration of these different dimensions shapes the paradigms that determine research choices. The current period is characterized by the need to identify new technical paradigms in the face of the environmental impasses created by the intensification models proposed by industrial agriculture.

A historical review of the process implemented with respect to plantain in Cameroon reveals a dynamics of institutional innovation based on hybridization of fundamental research (botany), systems research (economics), experimental research (agronomy), and participatory research (interdisciplinary) which resulted in the periodization of hybridization as described below.

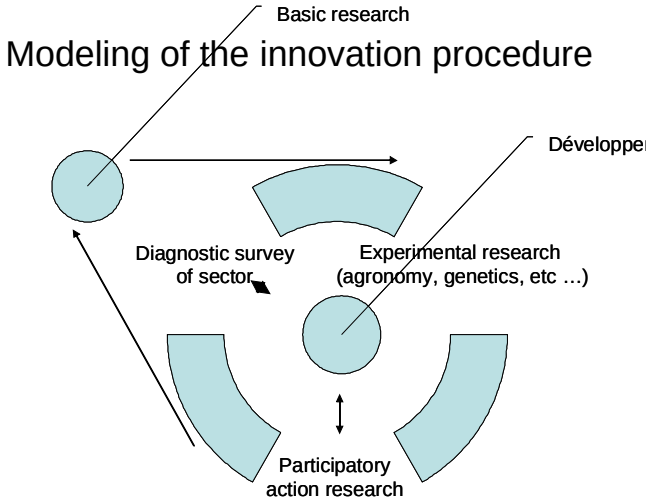
From technical to institutional innovation

The first stage in which two types of research were juxtaposed:

11 Pesticides can be dangerous for the biodiversity or the human health, the badly used angrais, can polluted waters.

- The search for a diagnostic system (1991) that brought together contributions from economics and agronomy enabled i) the socio-economic conditions that govern the production, marketing and consumption (sector) of plantain to be characterized; ii) the hierarchy of intervention priorities to be established, and finally a critical review to be made of the orientation of experimental research, which is sometimes disconnected from empirical reality. Methods of participative investigations were used in this phase

- A study (derived from the researchers' empirical perception) based on fundamental research in botany, explained the emergence of the apical bud in banana. This stage (which occurred before 1998), lasted 6-8 years and led to a better understanding of the failure of the in-vivo multiplication techniques practiced up to then (invention) but not adopted by farmers. It resulted in a technique for multiplying planting material from stem fragments (Kwa, 2003). At a complementary level, techniques for integrated control (trapping of weevils, stripping leaves [12]) were initiated at the research station, along with the creation of hybrids resistant to black cercosporiosis [13].



The first stage led researchers at the stations (given the environment and the sum of constraints) to produce technical inventions. The creation of interactions between the two studies was undertaken simultaneously by an observatory that monitored farms and markets, and the diffusion of techniques implemented in the region that supplies Douala (South-west and Coastal provinces) by providing training specialized for technicians from the Ministry of Agriculture.

The second stage (1999-2003) led to a set of technical proposals (multiplication techniques, integrated control) being adapted to the range of different production conditions (and thus constraints) and locations. This adaptation was made possible by the involvement of researchers in the creation of institutional frameworks through contracts with different types of private partnerships (with companies and NGOs), national and international public partners in Southern and Western

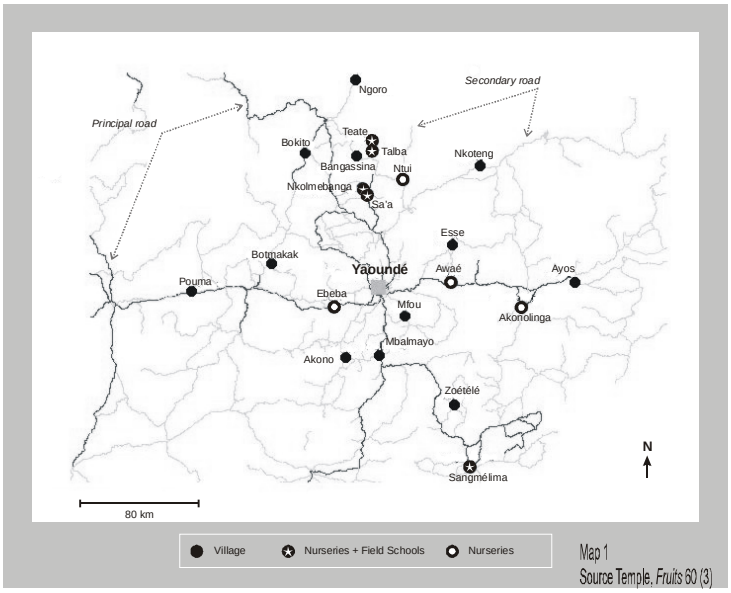
12 Control of weevils by paring suckers (neem) and trapping; control of black cercosporiosis by stripping leaves, changing the planting calendar; control of nematodes by crop rotation (amaranthus, etc), fallow, paring suckers in hot water, etc.

13 Black cercosporiosis, a leaf disease, affects both quality and yield in industrial banana plantations (concentration in space, large high-density plots, etc.). When production is dispersed, the disease is easier to control and has less impact than root problems.

provinces [14]. This system involved negotiations between researchers and development projects, public authorities, and operational partners: groups of producers, NGOs, and also negotiations between researchers from different disciplines (economists, agronomists, nematologists, phytopathologists, geneticists) and a network of experimental farmers. The process was finalized in 2002 by the elaboration -on the initiative of the researchers- of a national development project for plantain that was appropriated and partially implemented by public authorities [15].

The dynamics of institutional innovation described above structured the interface between the researchers, farmers and technicians by simultaneously mobilizing:

- The main methodological principles of action research that involve the researcher in creating the conditions that enable technical change to be accomplished;
- The tools of participatory research (Sanginga, 2004) that ensure that proposals resulting from experimental research are validated in real production conditions and involve farmers in the evaluation of the results.



Map 1
Source Temple, *Fruits* 60 (3)

In the South-West and Coastal provinces the project relied on an observatory that monitored farms and markets. The production of information on markets enabled analysis of the structure of marketing costs and of the distribution of value in the different channels. This analysis revealed dysfunctions such as an increase in the discrepancy between prices in production areas and consumption areas that led public authorities to hold national surveys and led to more transparent markets (INS, 2005). The impact of these studies on the reduction of transaction costs due to improved circulation of information concerned markets is not analyzed here.

In the Central and Southern provinces, the scheme was set up around a network of experimental farmers and relay institutions that were responsible for maintaining training plots and demonstration nurseries (Mao 2). Participatory training courses were given by researchers between 2001 and 2003 [16].

The third stage (underway since 2003) continued the second stage in the Coastal and South-West provinces, and, more recently in Western provinces. In Central and Southern provinces

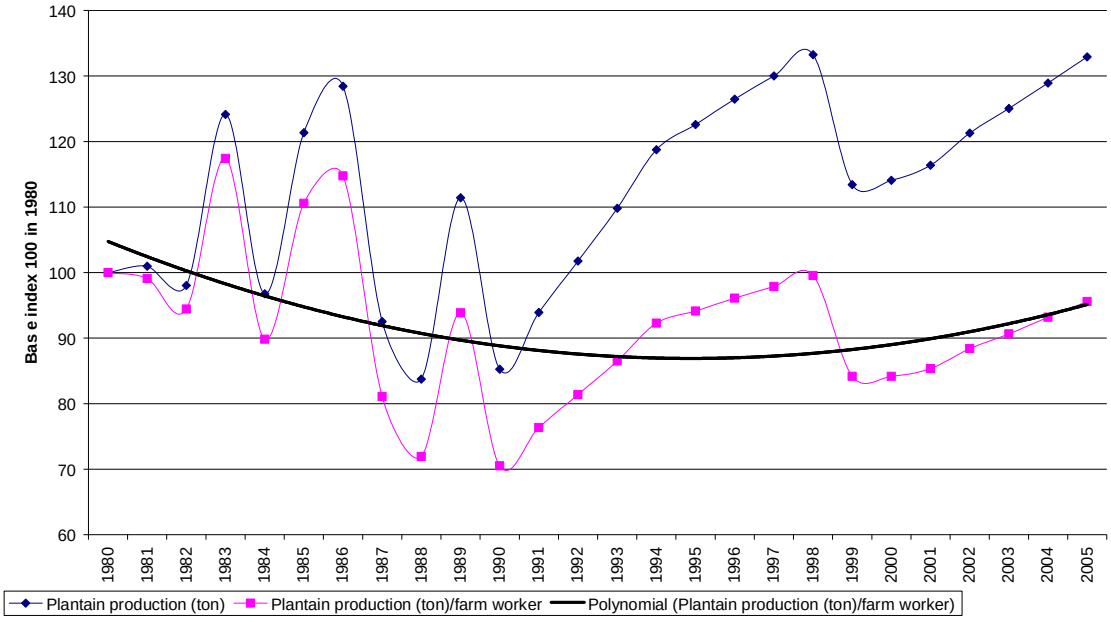
14 Project for the diffusion of techniques for integrated control (AVENTIS), Rural Development Project (European Union), Action research project for outlying urban areas (Ministry of Research, Cameroon).
15 National development project for plantain implemented by the Ministry of Agriculture.
16 These brought together more than 80 farmers, of whom 40 were delegates from farmers' groups, representing more than 1000 producers and 90 managers (from the Ministry of Agriculture and NGOs) for 60 days of training.

[17], a monitoring and evaluation survey based on questionnaires was conducted between 2002 and 2004 on a sample of 90 farms, and in 2006, a participatory survey was organized with farmers and managers. Monitoring of the scheme enabled i) identification of factors that limit the diffusion of techniques; ii) evaluation in terms of adoption and impact (social, economic impact, etc.); and iii) identification of the extent to which the removal of bottlenecks results in new technical needs and new risks.

III. Impacts on sustainable development?

The evaluation of the impact of the above-mentioned innovations on sustainable development implies the use of socio-economic and environmental indicators. It raises the methodological problem not only of access to reliable data but also of establishing causal relations between externalities linked with the production of knowledge and results that are partially induced by such externalities. These difficulties necessitate crossing different sources of information.

Figure 1 - Plantain production in Cameroon since 1980



The first indicator selected concerned changes in productivity[18] which was formerly unstable or on the decrease for plantain, but, since 1991, has tended to increase (Graph 1). Several different hypotheses may explain this phenomenon. The first supposes that farmers have increased the area of land under plantain without changing their cultivation techniques. However data on the amount of land under plantain do not support this hypothesis. The second questions the validity of the data used. We do not have the statistical means to check the validity of this hypothesis. The third leads us to suppose that the process of innovation and support provided by research that began in 1988 have influenced the reversal of the trend observed. We propose to test this hypothesis by analyzing the adoption of technical changes

17 In these provinces, IITA, which sent its technicians to Carbap for training in new multiplication techniques ,also played a complementary role in the diffusion of the innovation techniques.

in an area of experimental action (the area that supplies the city of Yaoundé). Afterwards we will attempt to characterize the relation between the increase in productivity and its impact on sustainable development, of which the fight against poverty is one component.

Impacts on the rate of adoption and diffusion of the innovations

The evaluation of impacts on the rate of adoption and on the diffusion of technical innovations (in the Central and Southern provinces) revealed the considerable success met by new techniques for the multiplication of planting material. The rate of adoption (57%) is high (i.e. the percentage of farmers who make significant use of the technique), but the rate of diffusion is even higher[19]. Techniques for integrated control of nematodes and weevils have also been widely adopted, though their rate of diffusion is considerably lower (Temple et al. 2007).

Impacts in the experimental area (Central and Southern provinces): in 2001, in the framework of the experimental scheme, 150 nurseries were created in collaboration with farmers; and in 2004, the national development project for plantain that was created as a result of the scheme (in the area concerned) distributed 800 000 plantlets or the equivalent of planting an average of 750 ha/year.

Impacts on ecological intensification

The appropriation of new multiplication techniques for planting material results in major changes in the management of banana plantations on family farms. In fact, it enables farmers to select varieties before planting. It also means the planting calendar can be adapted to the needs of the variety concerned and to existing soil and climate conditions. The result is an increase in planting density. In the 70 ha experimental area, in natural conditions, planting density more than doubled, increasing from an average of 300 to 700 banana plants per plot.

The need to supply nurseries with healthy suckers has lead 65% of the farmers to establish plots for multiplication close to their homes that are also used to experiment integrated pest control and organic fertilization. This technique, which enables varietal homogeneity to be controlled, has lead to the creation of special plots dedicated to the varieties most in demand by urban consumers. Table 2 illustrates this development and shows that two varieties are the most frequently chosen.

18 As an indicator of productivity, we used the ratio of the production of plantain to the number of practicing farmers.

19 Each year one farmer who masters the technique trains more than 14 other farmers.

Table 2 : Variatal diversiy used by PIF producers

Varieties multiplied by PIF	Number	%
Essong	42335	53.8
Elat	19845	25.2
Divers	7870	10
Assugbegle	5410	6.9
Otouga	3000	3.8
Other	190	0.24
TOTAL	78650	1.00

Sample of 10 nurseries – 2005 -

« Essong » and « Elat » represent 75% nursery production. Hybrids that are resistant to black cercosporiosis provided by research for testing (Crbp39) (included in the category « other » in Table 2) have only been multiplied to a limited extent and consequently rarely adopted.

The diffusion of new techniques creates a risk of varietal homogeneity in the plots (there are currently around 12 varieties per plot). On the basis of the sample we surveyed, the new technique have increased yield by 10 and 30% due to a reduction of losses caused by parasites (healthy planting material), increase in the weight of the bunches, increase in density, improved management of cultivation thanks to homogeneity of the plots. Experimental results of the observations we made showed an increase in the quantity of work of between 10 and 20%. The increase in yield -thanks to ecological intensification- reflects an increase in the intensity of work and an increase in labor productivity without the use of chemical inputs.

This intensification leads to a disconnection between the current increase in the supply of plantain (graph 1) and the continued and increasing cultivation of new land. It should be recalled that cultivating forest areas currently under long-term fallow generally implies burning trees with negative consequences for the greenhouse effect. The result is positive externalities concerning the protection of forest reserves, biodiversity and the greenhouse effect that cannot be discussed in the framework of this paper.

Impact on the increase in incomes in rural areas

The widely dispersed production of plantain mainly takes place on family farms (around 5000 000 farms in Cameroon). The increase in labor productivity (without the use of inputs) increases income from diversification on small farms by means of two main mechanisms. First, a mechanical effect due to the increase in the volume of product sold linked to the increase in physical productivity. Second, the change in marketing conditions: the homogenization of varieties and of the ripe stage, and the spatial concentration of production (at the scale of the farms and of the whole supply area) reduce the cost of marketing[20] as well as the transaction cost. The farmers group their sales thereby enabling them to increase their ability to negotiate wholesale prices. In another connection, they acquired « a reputation for quality » and are on the way to becoming « professionals ».

One quality indicator that is important for wholesalers in the banana sector is homogeneity of ripeness and of varieties, which reduce losses due to logistics. The *bayams sellam* prefer to buy products produced by PIF, and this has resulted in an increase in the price paid to the producers - which has not yet been evaluated. In rural areas, income from plantain is generally used to satisfy basic needs and in certain situations to finance investment in other

20 Increase in the yield of varieties that are homogenous in terms of ripeness enabling sales to be grouped and resulting in considerable savings in the cost of transport as well as allowing producers to draw up sales contracts with buyers (reduction in transaction costs).

crops (cocoa, coffee). It contributes to the fight against poverty in rural areas and reduces migration by rural populations to towns.

Two other contributions to the fight against poverty should be underlined. The first is linked to the professional behavior of a certain number of nurserymen (creation of a new profession) who group their nursery work for plantain with other crops (fruit trees, palm trees, cocoa). At another level, the supply of plantain is better suited to the logistics of supplying towns (homogeneous and regular quantities, sufficient supplies) improving the competitiveness of the plantain with respect to imported food products (cereals)[21.]

Impacts on human and social capital

The process currently underway is improving the capacity of farmers to understand ecosystems, to understand relations between plants and disease, and the management of banana plantations (scheduling sales). The creation of this shared human capital enables farmers[22] to improve their capacity to analyze the technical transformations that are taking place by combining their experience with knowledge produced by research. The reinforcement of their understanding of plantain speeds up their capacity to specialize: the majority of nurserymen have become large-scale producers of plantain. It transforms the ways in which farmers are involved in marketing by introducing contracts. Improvement in the cognitive capacity of the farmers also affects their ability to negotiate with researchers and management structures (including NGOs).

Contribution to social capital: institutional to organizational innovation

Mastery of specific know-how results in collective recognition of the nurserymen who are then called on by other farmers to organize training sessions for new converts « *being a nurseryman has given me an identity and increased my social recognition and prestige* ».

This has resulted in the creation of social capital whose mobilization by the farmers has institutionalized horizontal coordination and given birth to socio-technical networks by legally identified organizations:

- The Inter-professional Banana Plantain Network (*Réseau Interprofessionnel de la Banane Plantain*, RIBAP) which groups around 50 farmer/nurserymen and managers, was set up in 2002 with the following objectives:
  - Ø To collect and circulate information (technical information, sales opportunities, etc.) between nurserymen and encourage the exchange of ideas;
  - Ø To collaborate on specific and mutually advantageous activities;
  - Ø To create a structure to tap sources of subsidies (public and private).
- Association of Producers of Plantain Bananas Lékié (ASPPLABAL established in 2001) that institutionalized a network of experienced planters for the purpose of producing plantlets.

21 However, improvements are still not sufficient, and this is reflected in the continued increase in the prices paid by urban consumers.

22. In the same way, the approach enables researchers to identify justifications for practices, to analyze their scientific pertinence, to understand why a technique is refused, and finally, to identify the environmental variables that could imply a given technique needs be adapted.

The existence of these « summit » organizations led to the creation of around ten other groups of producers (GIC) who focus their activities on the multiplication of planting material and diffuse either the techniques themselves or the knowledge required for their implementation by two means:

- By organizing *participatory training courses* for non-members: in exchange for the transfer of know-how, the participants provide the inputs needed for the seedbed (sawdust etc) and suckers to multiply that will belong to the owner of the seedbed.
- By *distributing PIF free of charge* to encourage farmers to see for themselves the difference in yield with the new planting material « *creation of new converts* »

This scheme produced a dynamics of organizational innovation that is a key element in the mechanism for the rapid diffusion of knowledge and technical proposals produced by research since 2002. Control of the homogeneity of the harvest calendar with respect to the stage of ripeness, which is linked with the ability of farmers to multiply suckers, also changes the terms of agreement with sellers. Beyond the horizontal forms of coordination mentioned above, this resulted in new forms of vertical coordination in marketing contracts that have not previously been described in this context. In this study, we did not check the relation between technical innovation and improved capture of its value within the sales chains.

Different externalities can also be mentioned. As far as positive externalities are concerned, the increase in the demand for water to irrigate the nurseries has led nurserymen to invest in digging wells that not only benefit other horticultural activities but also fulfill family needs. Concerning negative externalities, the fact the nurseries are located close to homes has resulted in serious infestation of termites in certain areas[23].

Conclusion

The questions that arise in connection with the adaptation of the supply of agricultural food products to the demands of urban markets and the limited natural resources that determine the performance of extensive production systems in food-producing agriculture in sub-Saharan Africa has led to strategies for ecological intensification that require a change in classical research pathways. This historical review of a scheme started in 1988 in Cameroon for plantain banana revealed how different forms of research (fundamental, diagnostic, action and participatory research) can be hybridized by relying on interactions between disciplines. Monitoring and evaluation revealed significant impacts in terms of productivity, the protection of natural resources and an increase in the income of family farms in rural areas. The exact quantification of these impacts is difficult as they result from externalities induced by systems of institutional and organization innovation that accompanied the implementation of the technical innovations. The process described here is part of the intensification of work and of ecological approaches to food-producing systems that increase productivity.

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23 The sawdust used in nurseries attracts termites.

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